HAMILTON HARBOUR

PHYSICAL PROCESSES

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**Ministry
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SUMMARY

Physical processes in the harbour and Burlington Canal were studied by operating current instruments from 1972 to 1975.

At the mid harbour locations, the net currents were towards the north during the unstratified period of winter. Under the ice-cover of Dec 72 - Jan 73, faster water movements were observed at the deeper location due to the restriction of ice-cover. The monthly resultant currents varied from 0.4 to 3.1 cm s^{-1} while the arithmetic average currents were 0.8-4.1 cm s^{-1}. Generally, faster currents were observed in the Ottawa Street Slip but slower water movements existed at the Redhill Creek locations.

High currents of up to 144 cm s^{-1} were recorded in Burlington Canal. Simple average current speed yields a mass exchange of 2-3 times larger than the results computed by the excursion - episode method.

The spectral periodicities of the currents indicate the presence of lakewide as well as local harbour influences on the water movements. Integral length scale of 0.4 to 7.7 m was computed at the mid harbour location. These length scales are useful in predicting the physical size of the phytoplankton patches.

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INTRODUCTION

Physical processes were studied in Hamilton Harbour, as part of the water quality study undertaken by the Ontario Ministry of the Environment (MOE) commencing in the Spring of 1972. MOE recognized the importance of biological, chemical and physical processes and their interactions on the harbour water quality in a dynamic environmental system (MOE, 1974, 1975 and 1977). Oxygen depletion in the deeper waters of the hypolimnion is a major concern during the summer period. Polak and Haffner (1978) showed that mass exchange between the Harbour and the lake, through Burlington Canal, was a major source of dissolved oxygen (DO) in the harbour. Kohli (1977) computed the total lake-harbour exchange to be 1% of the harbour volume per day while the net exchange toward the lake was about 0.5% of the harbour volume per day.

Hamilton Harbour is a natural harbour containing $280 \times 10^6 \text{ m}^3$ of fresh water (MOE, 1974) with a mean depth of 13 m. It is located in the northwest corner of Lake Ontario. It is an active port supplying the needs of the heavy industries on the southern shores. This industry uses and recirculates $27 \text{ m}^3 \text{ s}^{-1}$ (0.83% of harbour volume per day) of harbour water. Municipal sewage outfalls discharge $3.2 \text{ m}^3 \text{ s}^{-1}$ (0.10% of harbour volume per day) of treated effluents to the harbour while several creeks add 4.1 $\text{m}^3 \text{ s}^{-1}$ (0.12% of harbour volume per day).

While some physical data have already been reported (MOE, 1974, 1975 and 1977; Kohli, 1977), this report presents and discusses all physical data collected in Hamilton Harbour and Burlington Canal during 1972-75.

Table 1 lists the details of current meter operations in Hamilton Harbour and Burlington Canal during 1972-75. All meters were operated in the epilmnion except at locations 112 and 113 which

were operated in the hypolimnion. All data (see Appendix 1)
collected were numerically smoothed and then partitioned into
monthly data set (records). Statistical analyses of water
velocities and temperatures were performed to determine the spatial
and temporal characteristics. Hourly values of current speed along
the two major compass directions were resolved and then subjected to
spectral analysis to help identify the physical mechanisms
associated with the water movements.

Integral length scale (Λ) is a measure of the statistical or
correlation distance between velocities at two points. Λ can be
computed by utilizing the variance density function E_n
corresponding to the frequency (n) as obtained by the spectral
analysis (see Appendix 1). Hinze (1959; p.166) considers wave
number (k)

$$k = 2\pi n/\bar{U} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (1)$$

instead of the frequency (n) where $\bar{U}$ is the measure of the velocity
field. An energy spectrum function E_k was also introduced such
that

$$E_k = \bar{U} E_n/2\pi \quad \dots\dots\dots\dots\dots\dots\dots\dots \quad (2)$$

Λ was then computed as

$$\Lambda = (\pi/2S^2) \int_0^\infty (E_k/k)dk \quad \dots\dots\dots\dots\dots \quad (3)$$

where S is the rms (root mean square) value of the velocity field
(see Appendix 1 for details). Dispersion is a function of the
integral length scale (Λ) and turbulence.

RESULTS

Currents

The resultant current velocity vectors during 1972-75 are presented
in Figure 1, and Table 2 summarizes the statistical characteristics

of water currents in Hamilton Harbour. The resultant currents in
the harbour were predominantly going towards the north for ten out
of thirteen times. Figure 1 shows that the resultant currents at
the mid harbour locaions (113 in hypolimnetic and 114 in epilimnetic
waters) were oriented towards the north during the unstratified
period of winter. However, the resultant currents in epilimnetic
water during the stratification of August and September 1975 were
towards the south and then changed towards the west during October
1975. At the harbour locations (113, 114, 116 and 118) the
resultant current magnitudes varied from 0.4 to 3.1 cm s^{-1} and the
arithmetic average speeds ranged between 0.8 and 4.1 cm s^{-1}. The
persistence factors were 0.23-0.79. Kohli (1978) found resultant
currents in the middle of Toronto Harbour to range from 1.1 to 2.8
cm s^{-1} with the persistence factors being 0.30 to 0.68. Figure 1
and Table 2 show that the currents were generally faster (4.5 to 6.4
cm s^{-1}) out of the Ottawa Street slip (location 115) with the
persistence factor of 0.93 to 0.95. The high persistence and faster
currents going out of the slip may be attributed to the average
industrial discharge of 14 m^3 s^{-1} into the slip.

Current measurements at two different depths (locations 113 and 114)
from a single tower revealed faster water movements at the deeper
location (113) during Dec 72 and Jan 73 (see Figure 1 and Table 2).
Surface waters normally have larger magnitude currents due to
surface wind stress, however, during the period of ice cover, the
reverse was found. The ice-cover formed by mid December 1972 and
persisted well beyond the end of January 1973 when instruments were
removed from the harbour. During the winter, the top layer of
Hamilton Harbour freezes over the warmer subsurface waters. The
frozen layer acts as a restriction to the deeper waters and results
in faster water motions.

Table 3 summarizes the important current statistics in the
Burlington Canal during 1972-75. The resultant currents varied from
1.1 to 15.1 cm s^{-1}, and the arithmetic average speed ranged
between 7.6 and 56.2 cm s^{-1}. The maximum speed recorded in the

channel was 144 cm s^{-1}. The relatively faster currents may be
attributed to the general constriction (van de Kreeke, 1976) and
Helmohtz mode of the harbour (Kohli, 1977). Figure 2 shows the
resultant current vectors in the Burlington Canal during 1972-75.
In Sept 72, Nov 72 and May 73, the resultant currents were going
towards the channel wall. This is rather misleading due to the
bimodal nature of currents (see Appendix 1 for detailed explanation).

Table 3 presents the mean speed going toward the harbour and the
lake with the corresponding percentages of occurrence. These can be
utilized to obtain a rough estimate of water flowing in either
direction. During Sept 75, a rough flow estimate as above resulted
in 4.3 x 10^6 m^3 d^{-1} towards the lake and 2.4 x 10^6 m^3 d^{-1}
towards the harbour. These flow estimates are about 2 to 3 times
larger than those computed by the excursion-episode method (Kohli,
1977) which eliminates the episodes not clearing the channel. The
excursion-episode method therefore provides a better estimate of
flow through the connecting channel. Mass exchange through the
Burlington Canal has not been included in this report since for most
periods, data are available at a single point only. A good data-set
was available at two levels for a reasonable mass exchange
computation during September 1975 and this has been reported (Kohli,
1977) separately.

Water Temperature

Table 4 presents a one-dimensional water temperature frequency of
occurrence in the harbour locations during June and July 74. The
mean water temperature at locations 115 and 116 varied from 2.7 to
7.3°C with standard deviations of 1.4 to 2.2°C. The mean water
temperatures at the Redhill Creek location (118) varied from 21.7 to
25.0°C with standard deviations of 1.4 to 2.4°C. Such a wide
difference in the mean water temperatures were due to the instrument
locations, above or below the thermocline and the proximity of
industrial outfalls to the study site. Vertical water temperature

profiles at these locations were not measured during June and July 74. However, the harbour waters are known to have a thermocline during June and July. The water temperatures at Ottawa Street Slip (115) were measured in the epilimnion (4.0 m from bottom and 4.6 m of water). At site 116, the instrument was also in the epilimnion i.e. 14.6 m from bottom in 18.3 m of water. The location 118 was 5.5 m from bottom in 10.7 m of water and probably in the epilimnion. The high temperatures at this site were due to the industrial discharges of DOFASCO, CIL and Firestone together with the generally stagnant waters of the area.

In Burlington Canal, mean water temperature varied from 9.8 to 24.0°C with standard deviations of 1.8 to 6.7°C (see Table 5) during the months of May to November. The maximum monthly temperature variation of 26°C occurred during Jul 73 at location 111 while the minimum monthly temperature variation was 6°C during Nov 72 at the same site.

Autospectra

The lakewide periodicities (17.1, 15.0, 12.0, 10.0, 8.6, 8.0, 7.5, 7.1, 6.4, 5.7 and 5.5 h) were observed at Hamilton Harbour locations (see Table 6). The periods of 17.1 and 15.0 h each were due to the lakewide seiches. Lunar tides were responsible for the 12.0 h periods observed in the harbour.

The lowest modes of longitudinal free oscillations of Lake Ontario were theoretically computed by Rockwell (1966) as 4.91, 2.97, 2.15, 1.63 and 1.29 h. Rao and Schwab (1974) calculated the lowest modes of free oscillations as 5.10, 3.11, 2.31, 1.87, 1.78 and 1.45 h. Most of these periods were observed in the harbour (see Table 6). The smaller periods of oscillation contribute to variability of harbour currents. Burlington Canal (see Table 7) exhibited a predominant influence of the lunar tides, as 12.0 h periods were observed during most of the study. The periods of 15.0 and 13.3 h observed in many data-sets reflected the lakewide effects of Lake

Ontario. Spectral periods of less than 5 h were found during all
records and may be attributed to the lowest modes of three
oscillations (Rockwell, 1966; Rao and Schwab, 1974). These small
spectral periods are probably due to the local effects of the canal
and contribute to the variability of the water movements in the
canal.

Integral Length Scales

Figure 3 shows a plot of kinetic energy spectrum function E_k and
the wavenumber k for the mid harbour location (114) in the
epilimnion. The plot had a general slope of -3.0 which is similar
to the results of Palmer (1973) in the nearshore area of Lake
Ontario. In Figure 3, as k increased from 0.24 to 14.28 cm^{-1},
E_k decreased rapidily from 9059 to 7.5 $cm^3.s^{-2}$. The value of
(E_k/k) dropped more rapidly with the increase of k. The equation
(3) was numerically integrated between k = 0.24 and 14.28 cm^{-1}.
It was observed that the integration for k 10.0 cm^{-1} yielded no
contribution to the results and therefore may be considered to have
been integrated to k = ∞. The computed integral length scales
(see Table 8) varied from 1.0 to 7.7 m along the north-south
direction and 0.4 to 3.0 m along the east-west direction. Palmer
(1973) computed the integral length scale of 2.4 m for the nearshore
and 4.3 m for the offshore location. The present results are,
therefore considered reasonable. As the scales were computed for
the epilimnion location (114), these may be applicable to the
surface waters. Integral length scales are generally related to the
physical spread of biomass patches of phytoplankton. The length
scales, together with the turbulence of the water, are important
factors in the dispersion characteristics of the water body.

CONCLUSIONS

The resultant currents at the mid harbour locations were towards the
north during the unistratified period of winter. However, the net
current direction in epilimnetic waters during the stratification of
August and September 1975 was towards the south.

The monthly resultant currents in the harbour where predominantly going towards the north and varied from 0.4 to 3.1 cm s^{-1}. The arithmetic, monthly average speed ranged between 0.8 and 4.1 cm s^{-1}. The currents in Ottawa Street Slip were generally faster. During the ice cover in 1972-73, faster currents were observed in deeper waters compared to the currents nearer the ice surface. This phenomenon was related to the restriction of the ice cover.

Burlington Canal recorded high currents of up to 144 cm s^{-1} probably due to the canal restriction. Mass exchange computed from simple average current speeds was found to be 2 to 3 times larger than as computed by the excursion - episode method (eliminating episodes that do not clear the confines of the channel).

Lakewide and semi-diurnal periodicities were observed in the harbour indicating the influence of the lake motions. The harbour also had the lowest 5 modes of Lake Ontario and smaller periods which reflect the influence of the local harbour geometry. Kinetic energy spectra at the mid-harbour locations was similar to those observed in the nearshore areas of Lake Ontario. Integral scale length of 0.4 to 7.7 m was computed from the kinetic energy spectrum at the mid harbour location in epilimnetic waters. These scales may be applicable to the harbour surface waters and useful in determining the physical size of the phytoplankton patches.

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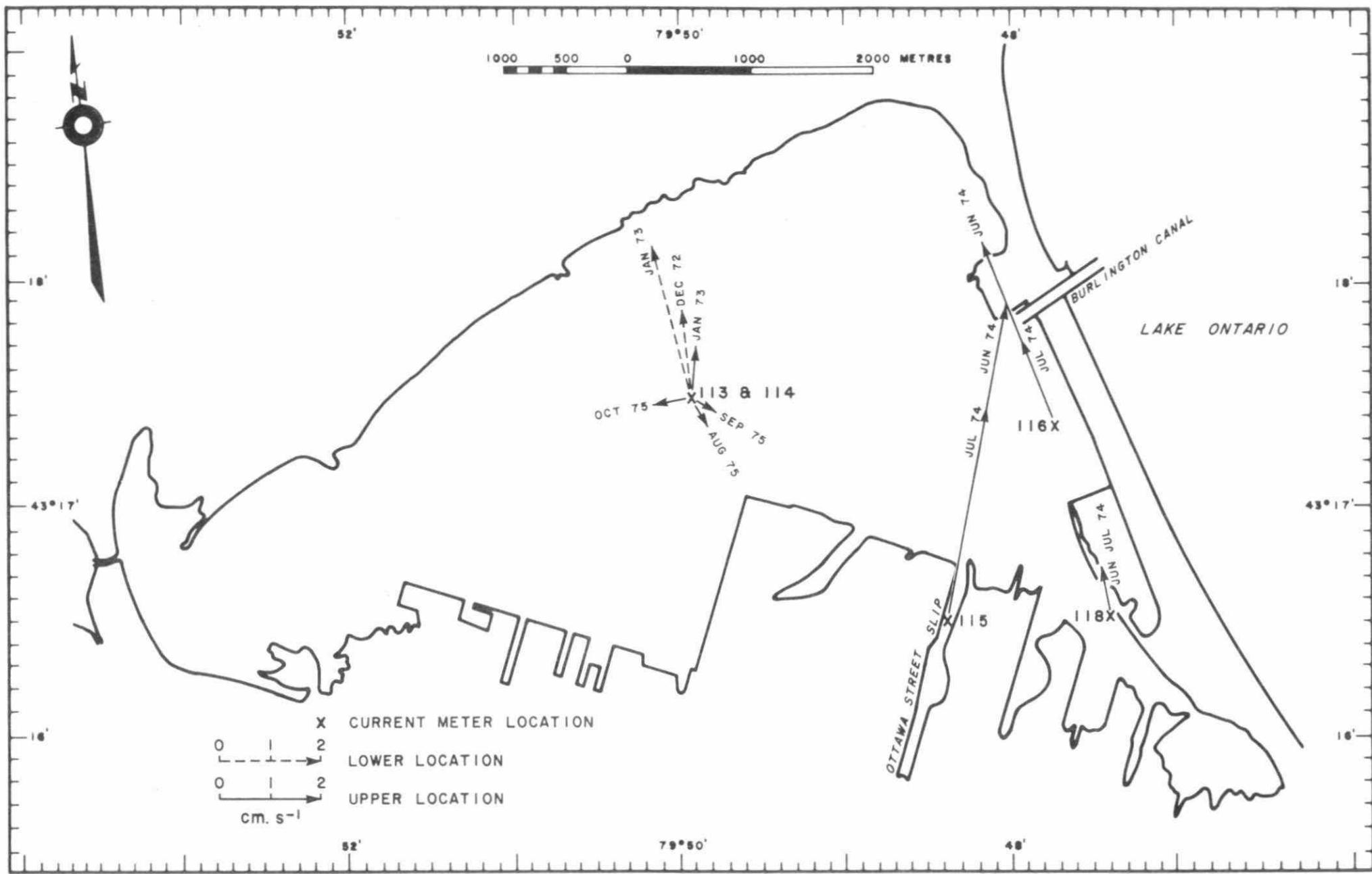
FIGURE 1 - RESULTANT CURRENTS IN HAMILTON HARBOUR, LAKE ONTARIO, (1972-75).
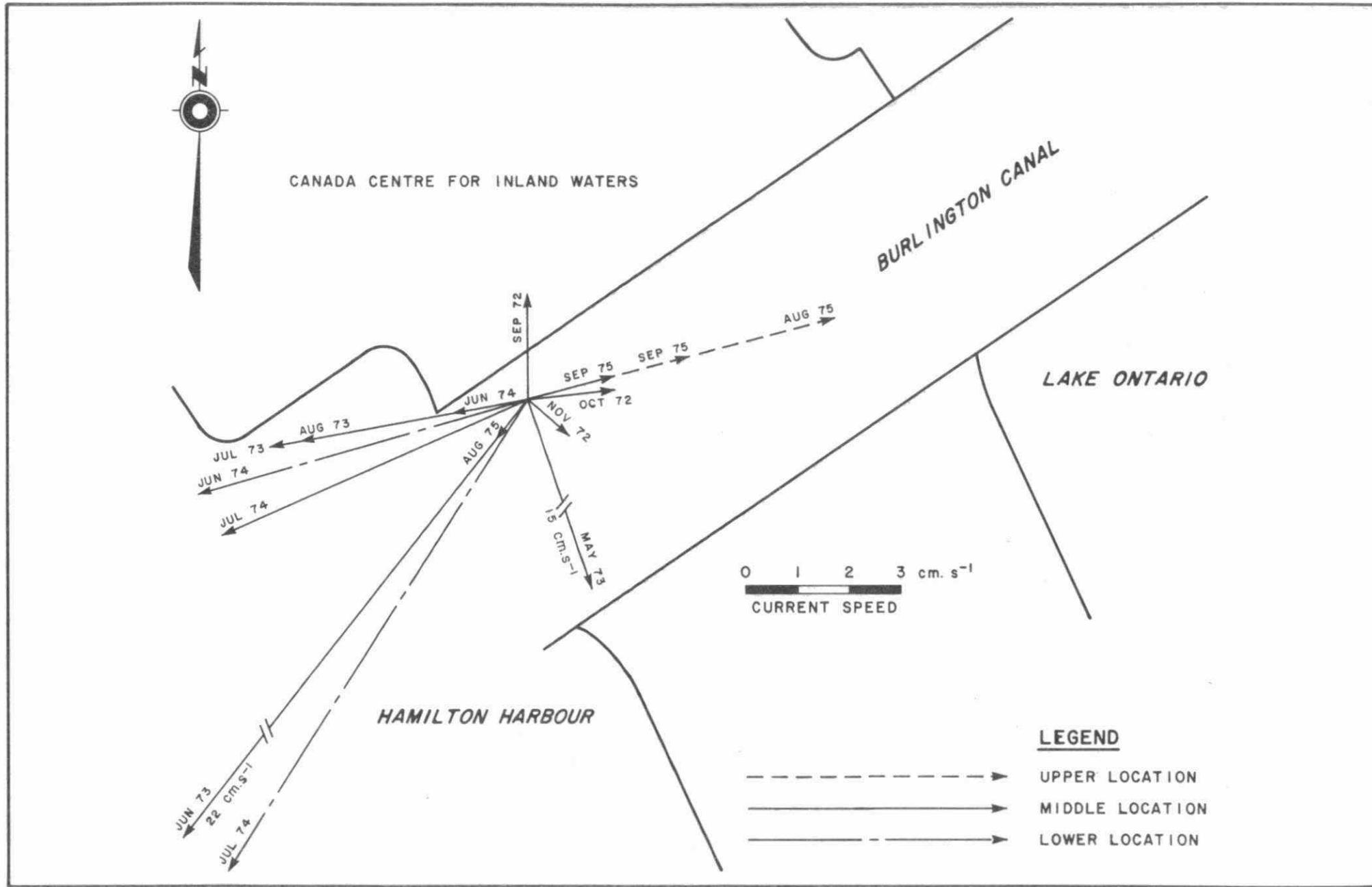
FIGURE 2 - RESULTANT CURRENTS IN BURLINGTON CANAL, (1972-75).
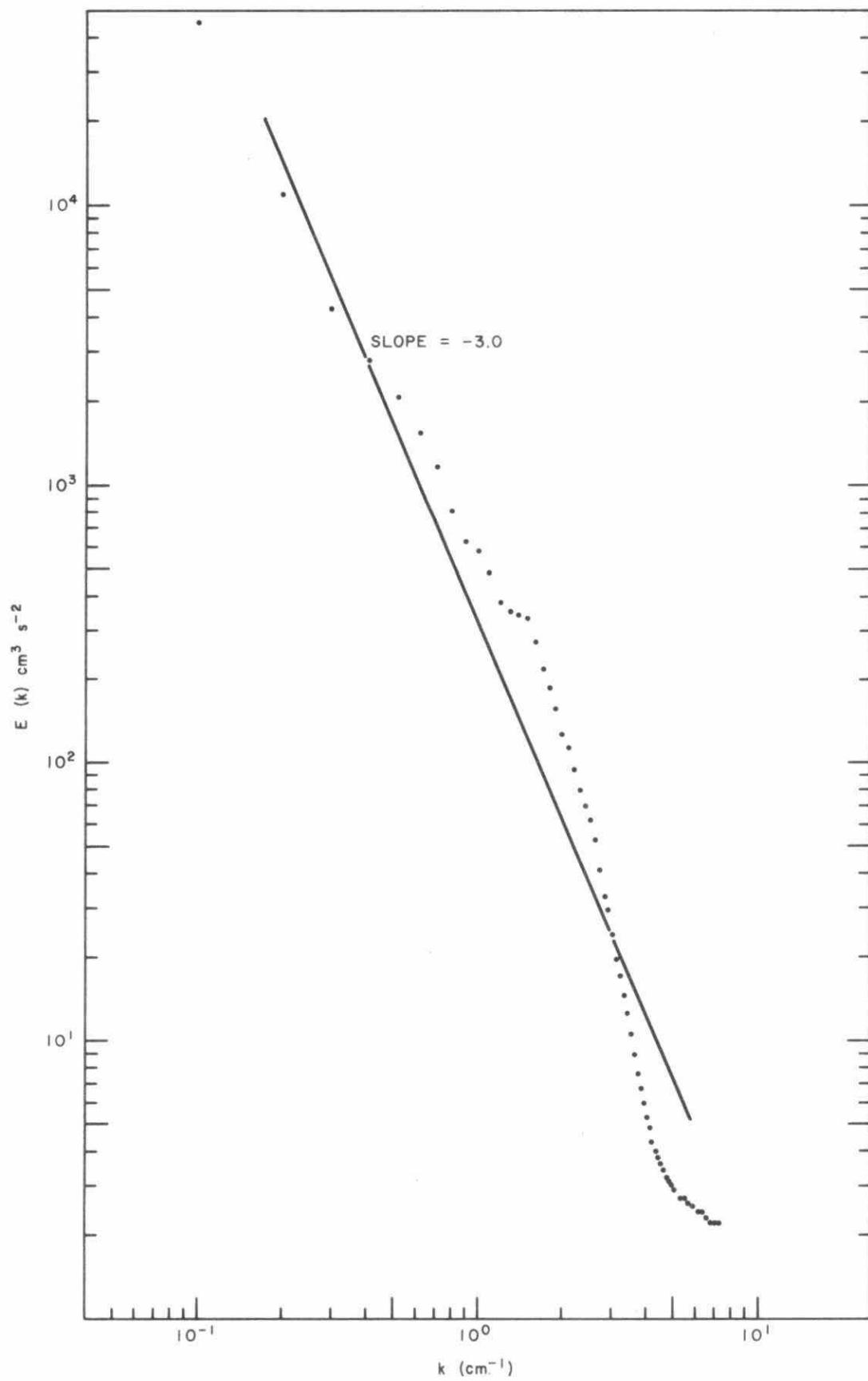
FIGURE 3 - KINETIC ENERGY SPECTRA FOR JAN. 73 HAMILTON
HARBOUR (LOCATION 114)

TABLE 1: Current Instrument Operations in Hamilton Harbour and
Burlington Canal, Lake Ontario 1972-75

Location Code	Instrument Type	Instrument No.	Instrument from Bottom (m)	Total Water Depth (m)	Period of Operation From	Period of Operation To
111	P*	144	6.1	9.4	11 Sep 72 28 Sep 72	24 Sep 72 2 Nov 72
111	P	206	6.1	9.4	3 Nov 72	10 Nov 72
111	P	164 436	6.1	9.4	4 May 73	22 Aug 73
111	P	239	6.1	9.4	14 Jun 74	22 Jul 74
111	P	207	6.1	9.4	14 Aug 75	30 Sep 75
111A	P	189	7.5	9.4	14 Aug 75	28 Sep 75
112	P	207	2.1	9.4	14 Jun 74	22 Jul 74
113	G**	039	6.1	22.9	15 Dec 72	31 Jan 73
114	G	038	16.3	22.9	14 Dec 72	31 Jan 73
114	G	279	16.3	22.9	7 Aug 75	4 Oct 75
115	G	027	4.0	4.6	14 Jun 74	18 Jul 74
116	G	025	14.6	18.3	14 Jun 74	22 Jul 74
118	P	189	5.5	10.7	15 Jun 74	22 Jul 74

*   Plessey
** Geodyne

All meters were operated in epilimnion except 112 and 113 which were
operated in hypolimnon.

TABLE 2:   Summary of Currents in Hamilton Harbour, Lake Ontario 1972-75

	HAMILTON HARBOUR LOCATIONS												
	1 1 3		1 1 4					1 1 5		1 1 6		1 1 8	
	Dec 72	Jan 73	Dec 73	Jan 73	Aug 75	Sep 75	Oct 75	Jun 74	Jul 74	Jun 74	Jul 74	Jun 74	Jul 74
Resultant direction coming from 0° as North	172	164	172	183	337	304	77	190	190	159	161	166	169
Resultant speed (cm.s^{-1})	1.82	3.08	0.41	1.11	0.59	0.48	0.76	6.41	4.46	2.89	1.77	0.97	1.09
Average speed (cm.s^{-1})	2.73	4.05	1.76	2.42	2.24	0.84	1.05	6.87	4.69	3.77	3.57	1.04	1.39
Maximum speed (cm.s^{-1})	35.17	35.77	9.41	15.09	11.13	9.69	5.38	27.15	17.50	12.67	13.20	8.80	10.55
Persistence factor	0.67	0.76	0.24	0.46	0.26	0.57	0.73	0.93	0.95	0.77	0.50	0.93	0.79
Percentage of negligible* speed (% of recording period)	6	3	2	7	24	52	53					60	48
Percentage of time going in direction of resultant	20	33	12	17	14	22	37	78	87	36	29	33	49
Total number of readings	4896	8929	4971	8929	3600	4320	436	4874	5057	4888	6247	2304	3099
Interval of readings (min)	5	5	5	5	10	10	10	5	5	5	5	10	10

*   <0.30 cm.s^{-1}

TABLE 3: Summary of Currents in Burlington Canal, Lake Ontario 1972-75

	BURLINGTON CANAL LOCATIONS												111A		112	
	111			111												
	PERIOD															
	Sep 72	Oct 72	Nov 72	May 73	Jun 73	Jul 73	Aug 73	Jun 74	Jul 74	Aug 75	Sep 75	Aug 75	Sep 7_	Jun 74	Jul 74
Resultant direction coming from 0° as North	0	263	312	341	39	80	78	82	66	41	255	260	252	74	33
Resultant speed (cm.s^{-1})	2.03	1.74	1.10	15.06	21.73	5.15	4.83	1.48	6.66	1.02	1.76	6.17	3.27	6.70	10.85
Average speed (cm.s^{-1})	9.38	10.59	13.87	55.21	56.19	8.85	7.63	8.13	7.80	8.31	7.94	11.78	8.23	10.28	12.54
Max. speed (cm.s^{-1})	45.08	122.7	42.59	142.5	143.7	60.08	31.54	42.90	39.75	44.51	44.23	46.50	44.94	40.61	41.25
Persistence factor	0.22	0.16	0.08	0.27	0.39	0.58	0.63	0.18	0.85	0.12	0.22	0.52	0.40	0.65	0.87
Percentage of negligible* speed (% of recording period)	0	1	1	1	0	0	1	3	5	5	20	2	20	2	2
Percentage of time going in direction of resultant	14	37	3	3	49	62	62	46	46	32	24	49	36	12	88
Percentage of time going towards lake	39	50	50	45	28	26	23	37	20	39	46	66	61	6	9
Mean speed going towards lake (cm.s^{-1})	8.58	11.69	11.63	41.77	41.35	6.60	5.55	8.87	9.11	8.88	10.86	10.11	7.91	7.76	6.21
Percentage of time going towards harbour	44	45	39	44	58	68	69	59	78	48	39	24	32	91	88
Mean speed going towards harbour (cm.s^{-1})	9.12	9.07	14.48	35.94	41.85	8.93	9.35	7.43	10.39	9.21	8.27	9.79	6.63	9.20	10.39
Total # of readings	1844	5045	1032	4027	3888	4464	3167	2248	2448	2588	4309	2591	3965	3102	3103
Interval of readings (mins)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

*   <0.30 cm.s^{-1}

TABLE 4: Temperature Frequency, Hamilton Harbour, Lake Ontario 1974

Temperature Range °C			LOCATION					
			1 1 5		1 1 6		1 1 8	
			PERIOD					
			Jun	Jul	Jun	Jul	Jun	Jul
0.00	-	0.99	0.25		6.00	18.57		
1.00	-	1.99	6.25			28.24		
2.00	-	2.99	19.50		0.50	22.05		
3.00	-	3.99	16.00	0.48		14.89		
4.00	-	4.99	24.00	16.14	0.75	5.42		
5.00	-	5.99	17.75	13.25	0.75	0.77		
6.00	-	6.99	16.25	23.86	8.50	0.97		
7.00	-	7.99		30.84	42.50	2.32		
8.00	-	8.99		8.43	33.50	3.68		
9.00	-	9.99		6.99	7.50	3.09		
15.00	-	15.99						
16.00	-	16.99						
17.00	-	17.99						0.78
18.00	-	18.99					4.45	1.96
19.00	-	19.99					3.93	1.76
20.00	-	20.99					20.94	3.33
21.00	-	21.99					34.29	4.89
22.00	-	22.99					20.42	6.46
23.00	-	23.99					8.12	6.65
24.00	-	24.99					7.85	14.48
25.00	-	25.99						21.53
26.00	-	26.99						19.18
27.00	-	27.99						14.68
28.00	-	28.99						3.33
29.00	-	29.99						0.39
30.00	-	30.99						0.59
Mean °C			4.28	6.71	7.33	2.69	21.69	24.98
Std. Deviation °C			1.48	1.44	2.00	2.22	1.40	2.41

TABLE 5:   Temperature Frequency, Burlington Canal, Lake Ontario 1972-75

Temperature Range °C	LOCATION														
	1 1 1											1 1 1 A		1 1 2	
	PERIOD														
	Sep72	Oct72	Nov72	May73	Jun73	Jul73	Aug73	Jun74	Jul74	Aug75	Sep75	Aug75	Sep75	Jun74	Jul74
0.00 - 3.99		0.12				7.24									
4.00 - 4.99		0.12				1.50									
5.00 - 5.99		0.48				3.01									
6.00 - 6.99		2.40	0.60			2.46								0.50	7.78
7.00 - 7.99	0.66	3.37	0.60		0.16	3.14	0.19		0.59					1.73	17.51
8.00 - 8.99	0.66	4.21	4.79	1.35	0.94	2.73	0.77		2.94					6.19	17.51
9.00 - 9.99	0.33	8.65	8.38	6.15	1.40	3.55	0.96	1.00	3.14					13.61	16.34
10.00 - 10.99	0.66	14.78	16.17	9.00	1.87	3.96	2.12	1.25	5.10	0.24				9.16	13.62
11.00 - 11.99	0.66	13.22	26.95	7.65	2.96	4.10	2.69	4.49	6.86	0.24				7.43	10.89
12.00 - 12.99	2.62	5.65	32.93	15.59	4.99	3.83	3.46	4.99	10.39	0.94	0.14			6.68	4.09
13.00 - 13.99	4.59	4.21	4.79	21.29	6.55	4.37	5.38	6.73	16.08	0.94	0.98		0.15	7.18	1.36
14.00 - 14.99	4.92	11.06	1.80	25.34	9.67	5.05	7.31	4.99	12.55	1.42	1.12		0.31	12.13	1.75
15.00 - 15.99	10.49	12.98		7.05	9.36	3.83	9.04	13.22	13.92	2.59	3.77	0.24	2.16	13.92	1.17
16.00 - 16.99	13.77	13.70		2.25	13.54	3.96	6.15	13.22	11.76	3.54	7.40	0.00	2.16	8.66	0.97
17.00 - 17.99	22.62	5.05		0.60	12.95	5.19	6.73	15.96	8.63	2.83	11.30	0.24	5.40	4.95	0.19
18.00 - 18.99	20.66				12.32	5.87	5.38	14.46	7.43	4.51	8.66	0.47	6.33	7.43	
19.00 - 19.99	15.08				10.76	6.83	9.81	10.97	2.35	10.38	12.15	5.90	12.69	3.22	
20.00 - 20.99	1.97				8.89	6.56	5.19	6.98	0.59	12.03	15.36	4.48	28.55	0.74	
21.00 - 21.99	0.33				2.03	8.47	7.88	1.75	0.59	12.74	20.67	7.08	21.45		
22.00 - 22.99					1.25	6.15	8.08			11.08	14.66	8.96	18.06		
23.00 - 23.99					0.16	8.20	18.85			14.15	3.49	14.39	2.01		
24.00 - 24.99										14.62	0.28	19.34	0.46		
25.00 - 25.99										4.48		17.69			
26.00 - 26.99										0.71		17.69			
27.00 - 100.00												3.54			
Mean °C	17.01	12.73	11.81	13.52	16.58	15.11	18.52	16.65	14.34	21.25	19.85	24.03	20.48	13.44	9.82
Std. Dev. °C	2.24	2.78	2.58	3.15	2.98	6.47	4.20	2.62	2.68	2.96	2.28	2.18	1.78	3.35	2.34

TABLE 6: Summary of Major Spectral Periods (hours)
80% Confidence Level
Hamilton Harbour, Lake Ontario

Location	Period	Data Averaged Over (h)	North-South	East-West
113	Dec 72	1	None	None
113	Jan 73	1	None	7.1,3.2,2.5*
114	Dec 72	1	10.0*,4.8*,3.9**, 2.6**,2.4	5.5*,3.9,3.2,2.6,2.2
114	Jan 73	1	12.0,4.0	None
115	Jun 74	1	12.0,3.1*,2.7*, 2.3	12.0,6.0**,4.6*,3.5, 3.0*,2.5,2.2*
115	Jul 74	1	15.0,5.5*,4.0**, 2.4**	4.0**
116	Jun 74	1	15.0,5.5*,4.6*,4.3*, 3.4*,3.2**,2.4	10.0**,5.5,3.8,3.3* 2.6
116	Jul 74	1	8.0,5.2,3.5,2.6	8.6*,7.5*,5.7,4.8
118	Jun 74	½	15.0,6.0,3.7,3.3, 2.6*,1.3,1.1	15.0**,5.5,3.2,1.8,1.4, 1.2,1.0**
118	Jul 74	½	10.0,4.6*,2.8,1.3	2.8,1.5,1.3
114	Aug 75	1	3.0*,2.2	15.0,8.6,4.6,4.1,2.8
114	Sep 75	1	17.1,10.0,7.5,5.5, 4.8	None

*   95% confidence level
**   99% confidence level

TABLE 7: Summary of Major Spectral Periods (hours)
80% Confidence Level
Burlington Canal, Lake Ontario

Location	Period	Data Averaged Over (h)	Along Channel	Across Channel
111	Sep 72	1	12.0*,5.5*,4.3*,3.2*, 2.4*	13.3*,4.8*,3.5,2.8,2.5*
111	Oct 72	1	12.0**,5.0**,3.2**, 2.4**	5.2**,3.2**,2.3*
111	Nov 72	1	3.2,2.1*,1.7,1.5**,1.1*	15.0*,2.1**,1.5**,1.1*
111	May 73	1	15.0,5.2,4.6**,3.0**, 2.4,2.1	15.0**,7.5,4.0,3.5, 3.0**,2.8,2.3*
111	Jun 73	1	10.0,4.6,2.9,2.4	5.2*,3.1,2.5
111	Jul 73	1	12.0**,5.0**,3.2**, 2.4*,2.2	12.0*,5.0**,3.2**,2.4*, 2.1
111	Aug 73	1	12.0**,5.0*,3.2**, 2.3*	12.0**,5.2**,3.2**,2.3
111	Jun 74	1	12.0**,5.0**,3.2,2.5*	12.0**,5.0**,3.2**,2.3**
111	Jul 74	1	12.0**,5.0**,2.3**	12.0**,5.0**,3.2*,2.3**
112	Jun 74	1	12.0,4.6,3.2,2.3	4.6,2.3**
112	Jul 74	1	12.0**,5.0**,3.2,2.4**	12.0**,5.0**,3.2**,2.4**
111A	Aug 75	1	12.0**,4.8**,3.2**, 2.4**	12.0**,4.8**,3.2**,2.4*
111A	Sep 75	1	12.0**,5.0**,3.3**, 2.4**,2.3**	12.0**,5.0**,3.2**,2.4, 2.3**
111	Aug 75	1	12.0**,5.0**,3.2**, 2.5,2.2*	13.3,7.5,3.2**,2.1
111	Sep 75	1	12.0**,4.8**,3.2**, 2.4*	13.3,7.5,5.5,4.8,3.3**

*   95% confidence level
**   99% confidence level

TABLE 8:   Summary of Integral Length Scales (m)

Location 114, Hamilton Harbour

LAG (h)	NORTH - SOUTH				EAST - WEST			
	Dec 72	Jan 73	Aug 75	Sept 75	Dec 72	Jan 73	Aug 75	Sept 75
60	3.73	7.65	1.69	0.98	0.39	0.77	2.33	3.04
40	2.79	5.81	1.40	0.84	0.30	0.64	1.76	2.45
30	2.29	4.81	1.27	0.74	0.24	0.56	1.39	2.05
20	1.71	3.68	1.14	0.60	0.17	0.46	1.00	1.54
Series Length (h)	414	744	600	720	414	744	600	720
Mean Speed (cm s^{-1})	0.40	1.03	0.44	0.19	0.04	0.15	0.22	0.34
RMS Speed (cm s^{-1})	1.00	2.55	2.39	1.03	1.00	4.36	2.44	1.17

APPENDIX 1

The data from all locations were pre-whitened (numerically smoothed)
after Blackman and Tukey (1959; p.29, 39, 74) using binomial weights
after Panofsky and Brier (1968; p.150).

Binomial distribution is generally applied to cases when two
alternatives are possible, e.g. a coin spun can land with either
head or tail. If N coins are spun independently, m heads and (N-m)
tails will show up. Smoothing functions can be made to approximate
the normal distribution curve by making the weights proportional to
the binomial distribution. The smoothing coefficients (C_m) are
computed thus:

$$C_m = N!/m! \ (N-m)! \ \ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

For data at 5 to 10 min intervals N=4 produced acceptable binomial
coefficients.

The binomial weights (S_m) for smoothing the data series are
obtained as follows:

$$S_m = C_m / \sum_{o}^{m} C_m \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (2)$$

Current speed and direction and water temperature data are smoothed
as above. However, if the instrument is operated in the Burlington
Channel, the direction is not smoothed since the movement in
channels are essentially along the channel axis.

The smoothed data are then partitioned into monthly records. For
each record, a two-dimensional frequency of occurrence of current
speed and direction were computed along with the resultant speed and
direction, mean and maximum current speeds and the persistence. The
current frequency tables along with the above results are presented
in Tables 1.01 to 1.28.

AUTOSPECTRA

Time series can be subjected to spectral analysis to help understand the physics underlying the variations in the time series by comparing the significant periods of time variation with the theoretical values. Statistically significant peaks indicate the likelihood or otherwise of variations with certain average peaks. As a prerequisite for spectral analysis, auto-correlation coefficients of the time series are computed. Auto-correlation coefficients are ordinary correlation coefficients of two members of the time series at different time lags.

Let U_i represent the time series. Auto-correlation coefficients may be computed as (Panofsky and Brier, p.138):

$$r_L = (U_i - \overline{U})(U_{i+L} - \overline{U})/N.s^2 \quad \dots \dots \dots \dots \dots \dots (3)$$

where r_L is the auto-correlation coefficient for the lag L.

$\overline{U}$ is the arithmetic average of the series U_i

N is the number of observations at time interval Δt.

s^2 is the variance of the series

s is the RMS (root mean square) value of the series.

Auto-correlation coefficients are utilized to compute the normalized spectrum B_i (Panofsky and Brier, p.143) for i = 1 to

$$B_i = (\Gamma_o/L) + (\Gamma_L/L)(-1)^i + \sum_{J=1}^{L-1} \left[\Gamma_J \cos(\pi i J/L) \right] \quad \dots (4)$$

Equation (4) results in greatly distorted spectral estimates whenever there are rapid fluctuations in the true spectrum. Spectral estimates are therefore smoothed by Hanning (Blackman and Tukey, 1959, p.34 and 171) as follows:

$$A_i = 0.25 B_{i-1} + 0.50 B_i + 0.25 B_{i+1} \quad \dots \dots \dots (5)$$

where A_i are the smoothed normalized spectral estimates.

The frequency (n) corresponding to the spectral estimate is computed as

$$n = i/2L\Delta t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

and the spectral estimates A_i or A_n are usually plotted against the frequency (n).

In order to determine the statistically significant periods of the spectral analysis the degrees of freedom (ν) associated with the spectrum are computed thus:

$$\nu = (2N-L/2)/L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Jenkins and Watts (1968; p.82) plotted the upper and lower limits for α = 0.01, 0.05 and 0.20 and $3 \leq \nu \leq 100$ (see Figure 1.01). The curves can be used to determine an interval within which a spectral peak may be expected to lie on $100(1-\alpha)$ % of occasions.

Palmer (1973) computed an integral length scale at a nearshore and offshore location in Lake Ontario. Integral length scale is a flow property and is a measure of the correlation distance between velocities at two points.

The normalized spectra A_n, is first converted to the energy spectra or variance density spectra E(n)

$$E_n = A_n \times s^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

Hinze (1959; p.54) showed that

$$\int_0^\infty E_n \, dn = s^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

It is convenient to redifine E_n in terms of a wave number k and the kinectic energy spectra E_k such that

$$\int_0^\infty E_k \, dk = s^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

$$E_k = \bar{U} \, E_n / 2\pi \quad \ldots\ldots\ldots\ldots\ldots \quad (11)$$

$$k = 2\pi n / U \quad \ldots\ldots\ldots\ldots\ldots \quad (12)$$

The integral length scale (Λ) may be computed that:

$$\Lambda = (\pi/2 \, S^2) \int_0^\infty (E_k/k) \, dk \quad \ldots\ldots\ldots\ldots \quad (13)$$

Bimodel Currents

Tables 3, 1.14, 1.16 and 1.17 show that during Sep 72, the currents were actually going towards the harbour (44% of time), the lake (39% of the time) and the resultant direction for a lesser (14%) percentage of time. Similarly, during Nov 72 and May 73, the currents were in the resultant direction for a mere 3% of time while they went towards the harbour for 39 and 44% and the lake for 50 and 45% of the time respectively. In all other cases, the resultant currents were either towards the harbour or the lake and for greater percentages of time (24 to 88%).

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TABLE 1.01

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50–22.49	22.50–67.49	67.50–112.49	112.50–157.49	157.50–202.49	202.50–247.49	247.50–292.49	292.50–337.49	ROW SUMS
0.0 –– 0.30	0.12	0.51	2.27	2.35	0.27	0.55	0.06	0.16	6.29
0.31 –– 1.99	0.51	1.37	15.50	11.11	3.78	4.25	3.64	0.96	41.12
2.00 –– 3.99	0.20	1.06	0.98	8.70	6.99	5.82	2.92	1.10	27.78
4.00 –– 5.99	0.04	0.39	0.14	3.51	4.98	4.78	1.49	0.49	15.83
6.00 –– 7.99	0.0	0.06	0.04	2.53	1.57	0.49	0.08	0.06	4.84
8.00 –– 9.99	0.0	0.0	0.0	1.02	1.53	0.02	0.0	0.02	2.59
10.00 –– 36.99	0.0	0.04	0.04	0.14	1.29	0.02	0.02	0.0	1.55
COLUMN SUMS	0.88	3.43	18.97	29.37	20.40	15.93	8.21	2.80	100.00

RESULTANT CURRENT IS   1.82 CM/S AT   172 DEG FROM NORTH   TOTAL NO. READINGS   4896

MEAN CURRENT IS   2.73 CM/S   PERSISTENCE IS   0.67

MAXIMUM CURRENT IS   36.00 CM/S   READINGS TAKEN EVERY 5 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN 22.9 M OF WATER

TABLE 1.02

LOCATION CODE : 1130   PERIOD   : JAN 73
AREA   : HAMILTON HARBOUR   LATITUDE : 43 17 28 N
LAKE   : ONTARIO   LONGITUDE : 79 49 56 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50–22.49	22.50–67.49	67.50–112.49	112.50–157.49	157.50–202.49	202.50–247.49	247.50–292.49	292.50–337.49	ROW SUMS
0.0 -- 0.30	0.18	0.50	0.34	0.38	0.50	0.75	0.10	0.03	2.79
0.31 -- 1.99	0.68	1.72	1.48	6.28	6.90	6.14	1.31	0.94	25.46
2.00 -- 3.99	0.25	1.08	1.64	6.10	11.58	5.03	0.91	1.21	27.79
4.00 -- 5.99	0.02	0.47	1.10	6.47	6.50	2.99	0.77	0.53	18.85
6.00 -- 7.99	0.01	0.24	0.37	7.06	5.43	1.71	0.10	0.17	15.09
8.00 -- 9.99	0.0	0.02	0.18	4.31	2.14	0.10	0.01	0.0	6.76
10.00 -- 36.99	0.0	0.0	0.0	2.44	0.74	0.09	0.0	0.0	3.27
COLUMN SUMS	1.14	4.03	5.10	33.05	33.79	16.81	3.20	2.88	100.00

RESULTANT CURRENT IS   3.08 CM/S AT   164 DEG FROM NORTH   TOTAL NO. READINGS   8929

MEAN CURRENT IS   4.05 CM/S   PERSISTENCE IS   0.76

MAXIMUM CURRENT IS   36.00 CM/S   READINGS TAKEN EVERY 5 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN 22.9 M OF WATER

TABLE 1.03

LOCATION CODE : 1140   PERIOD   : DEC 72
AREA   : HAMILTON HARBOUR   LATITUDE : 43 17 28 N
LAKE   : ONTARIO   LONGITUDE : 79 49 56 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50–22.49	22.50–67.49	67.50–112.49	112.50–157.49	157.50–202.49	202.50–247.49	247.50–292.49	292.50–337.49	ROW SUMS
0.0 -- 0.30	0.08	0.18	0.12	0.40	0.40	0.24	0.14	0.12	1.69
0.31 -- 0.99	3.04	5.17	5.49	8.01	2.43	3.10	1.75	2.55	31.54
1.00 -- 1.99	2.55	2.41	2.57	12.77	3.12	3.78	4.02	5.49	36.73
2.00 -- 2.99	0.62	1.47	0.89	1.93	2.35	3.22	1.47	1.99	13.94
3.00 -- 3.99	0.32	1.31	0.44	1.21	1.35	1.51	0.38	1.13	7.64
4.00 -- 4.99	0.12	0.56	0.26	0.72	1.29	1.31	0.22	0.48	4.97
5.00 -- 9.99	0.06	0.26	0.08	0.74	0.93	0.95	0.10	0.36	3.48
COLUMN SUMS	6.80	11.37	9.86	25.79	11.87	14.10	8.09	12.13	100.00

RESULTANT CURRENT IS   0.41 CM/S AT   172 DEG FROM NORTH   TOTAL NO. READINGS   4971

MEAN CURRENT IS   1.76 CM/S   PERSISTENCE IS   0.23

MAXIMUM CURRENT IS   9.41 CM/S   READINGS TAKEN EVERY 5 MIN

METER OPERATED AT   16.3 M FROM BOTTOM IN 22.9 M OF WATER

TABLE 1.04

LOCATION CODE : 1140   PERIOD : JAN 73
AREA   : HAMILTON HARBOUR   LATITUDE : 43 17 28 N
LAKE   : ONTARIO   LONGITUDE : 79 49 56 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50– 22.49	22.50– 67.49	67.50– 112.49	112.50– 157.49	157.50– 202.49	202.50– 247.49	247.50– 292.49	292.50– 337.49	ROW SUMS
0.0 –– 0.30	0.15	0.24	0.55	0.24	1.12	3.68	0.71	0.50	7.18
0.31 –– 0.99	1.10	2.23	1.71	2.25	3.23	8.66	2.63	2.62	24.43
1.00 –– 1.99	0.86	2.62	2.98	3.88	2.65	5.68	2.30	2.53	23.50
2.00 –– 2.99	0.27	1.37	1.16	2.89	2.80	4.05	1.89	1.37	15.80
3.00 –– 3.99	0.17	0.74	0.39	2.32	1.87	2.59	0.88	0.74	9.70
4.00 –– 4.99	0.10	0.60	0.31	1.94	1.15	1.43	0.55	0.40	6.50
5.00 –– 15.99	0.22	0.76	0.45	3.46	3.37	3.26	0.68	0.69	12.90
COLUMN SUMS	2.87	8.56	7.56	16.97	16.19	29.35	9.64	8.86	100.00

RESULTANT CURRENT IS 1.11 CM/S AT 183 DEG FROM NORTH TOTAL NO. READINGS 8929

MEAN CURRENT IS   2.42 CM/S   PERSISTENCE IS   0.46

MAXIMUM CURRENT IS   15.00 CM/S   READINGS TAKEN EVERY 5 MIN

METER OPERATED AT 16.3 M FROM BOTTOM IN 22.9 M OF WATER

TABLE 1.05

LOCATION CODE : 1140
AREA : HAMILTON HARBOUR
LAKE : ONTARIO

PERIOD : AUG 75
LATITUDE : 79 49 56 W
LONGITUDE : 43 17 28 N

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	2.56	3.94	3.92	4.92	1.75	2.78	2.36	1.78	24.00
0.31 -- 0.99	2.47	2.06	2.36	1.22	1.08	1.97	1.78	1.94	14.89
1.00 -- 1.99	3.94	2.31	2.83	0.89	1.22	2.06	2.94	2.58	18.78
2.00 -- 2.99	2.28	1.50	0.94	0.44	1.17	1.19	1.83	1.64	11.00
3.00 -- 3.99	1.67	1.14	0.69	0.33	0.31	0.69	1.11	1.78	7.72
4.00 -- 4.99	0.64	1.31	1.56	0.03	0.33	0.86	1.92	1.31	7.94
5.00 -- 11.99	1.28	2.03	3.67	0.39	0.28	1.00	4.08	2.94	15.67
COLUMN SUMS	14.83	14.28	15.97	8.22	6.14	10.56	16.03	13.97	100.00

RESULTANT CURRENT IS   0.59 CM/S AT 337 DEG FROM NORTH   TOTAL NO. READINGS   3600

MEAN CURRENT IS   2.24 CM/S   PERSISTENCE IS   0.26

MAXIMUM CURRENT IS   11.13 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   16.3 M FROM BOTTOM IN 22.9 M OF WATER

TABLE 1.06

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50–22.49	22.50–67.49	67.50–112.49	112.50–157.49	157.50–202.49	202.50–247.49	247.50–292.49	292.50–337.49	ROW SUMS
0.0 -- 0.30	9.44	5.05	4.79	3.50	2.59	5.72	9.86	11.32	52.27
0.31 -- 0.99	2.34	1.44	1.69	0.88	0.79	1.85	3.98	4.17	17.13
1.00 -- 1.99	2.31	1.02	1.64	1.23	0.21	1.78	3.15	5.30	16.64
2.00 -- 2.99	0.74	0.46	0.35	0.16	0.02	0.76	1.99	1.53	6.02
3.00 -- 3.99	0.62	0.25	0.25	0.21	0.19	0.21	1.20	0.79	3.73
4.00 -- 4.99	0.42	0.07	0.23	0.0	0.02	0.02	0.56	0.39	1.71
5.00 -- 9.99	0.14	0.37	0.05	0.0	0.0	0.09	1.37	0.49	2.50
COLUMN SUMS	16.02	8.66	9.00	5.97	3.82	10.44	22.11	23.98	100.00

RESULTANT CURRENT IS   0.48 CM/S AT 304 DEG FROM NORTH   TOTAL NO. READINGS   4320

MEAN CURRENT IS   0.84 CM/S   PERSISTENCE IS   0.57

MAXIMUM CURRENT IS   9.69 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   16.3 M FROM BOTTOM IN 22.9 M OF WATER

TABLE 1.07

LOCATION CODE : 1140
AREA : HAMILTON HARBOUR
LAKE : ONTARIO

PERIOD : OCT 75
LATITUDE : 79 49 56 W
LONGITUDE : 43 17 28 N

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50– 22.49	22.50– 67.49	67.50– 112.49	112.50– 157.49	157.50– 202.49	202.50– 247.49	247.50– 292.49	292.50– 337.49	ROW SUMS
0.0 -- 0.30	3.90	4.36	18.81	0.69	1.61	0.69	20.64	1.83	52.52
0.31 -- 0.99	0.69	5.28	4.36	0.69	0.0	0.0	0.69	0.69	12.39
1.00 -- 1.99	0.0	1.15	3.67	0.0	0.0	0.0	7.80	0.0	12.61
2.00 -- 2.99	0.0	0.46	5.50	0.0	0.0	0.0	0.69	0.0	6.65
3.00 -- 3.99	0.0	0.92	6.88	0.69	0.0	0.0	0.0	0.0	8.49
4.00 -- 4.99	0.0	0.0	4.59	0.0	0.0	0.0	0.0	0.0	4.59
5.00 -- 5.99	0.0	0.0	2.52	0.0	0.0	0.0	0.0	0.23	2.75
COLUMN SUMS	4.59	12.16	46.33	2.06	1.61	0.69	29.82	2.75	100.00

RESULTANT CURRENT IS   0.76 CM/S AT   77 DEG FROM NORTH   TOTAL NO. READINGS   436

MEAN CURRENT IS   1.05 CM/S   PERSISTENCE IS   0.73

MAXIMUM CURRENT IS   5.38 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   16.3 M FROM BOTTOM IN   22.9 M OF WATER

TABLE 1.08

LOCATION CODE : 1150
AREA   : HAMILTON HARBOUR
LAKE   :   ONTARIO

PERIOD   : JUN 74
LATITUDE : 43 16 30 N
LONGITUDE : 79 48 24 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
1.00 -- 2.99	0.0	0.0	0.0	0.0	14.65	5.72	0.0	0.0	20.37
3.00 -- 4.99	0.0	0.0	0.0	0.08	13.93	5.95	0.02	0.0	19.98
5.00 -- 6.99	0.02	0.02	0.04	0.25	18.24	3.26	0.06	0.04	21.93
7.00 -- 8.99	0.12	0.06	0.08	0.27	7.22	1.95	0.06	0.08	9.85
9.00 -- 10.99	0.04	0.08	0.16	0.21	4.49	1.29	0.27	0.06	6.61
11.00 -- 12.99	0.18	0.04	0.10	0.39	9.56	0.47	0.27	0.08	11.10
13.00 -- 27.99	0.0	0.02	0.0	0.10	9.56	0.37	0.08	0.02	10.16
COLUMN SUMS	0.37	0.23	0.39	1.29	77.66	19.02	0.76	0.29	100.00

RESULTANT CURRENT IS   6.39 CM/S AT   190 DEG FROM NORTH   TOTAL NO. READINGS   4874

MEAN CURRENT IS   6.87 CM/S   PERSISTENCE IS   0.93

MAXIMUM CURRENT IS   27.15 CM/S   READINGS TAKEN EVERY 5 MIN

METER OPERATED AT   4.0 M FROM BOTTOM IN   4.6 M OF WATER

TABLE   1.09

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50– 22.49	22.50– 67.49	67.50– 112.49	112.50– 157.49	157.50– 202.49	202.50– 247.49	247.50– 292.49	292.50– 337.49	ROW SUMS
1.00 -- 1.99	0.0	0.0	0.0	0.02	31.09	3.99	0.0	0.0	35.10
2.00 -- 2.99	0.0	0.0	0.0	0.02	6.43	1.52	0.0	0.0	7.97
3.00 -- 3.99	0.0	0.0	0.0	0.0	6.25	0.28	0.0	0.0	6.53
4.00 -- 4.99	0.02	0.0	0.0	0.04	14.34	0.89	0.0	0.0	15.29
5.00 -- 5.99	0.0	0.0	0.06	0.0	3.40	1.03	0.0	0.02	4.51
6.00 -- 6.99	0.0	0.04	0.04	0.08	3.10	0.75	0.0	0.02	4.03
7.00 -- 17.99	0.24	0.24	0.32	0.91	22.35	2.23	0.10	0.20	26.58
COLUMN SUMS	0.26	0.28	0.42	1.07	86.95	10.70	0.10	0.24	100.00

RESULTANT CURRENT IS   4.46 CM/S AT 190 DEG FROM NORTH   TOTAL NO. READINGS   5057

MEAN CURRENT IS   4.69 CM/S   PERSISTENCE IS   0.95

MAXIMUM CURRENT IS   17.50 CM/S   READINGS TAKEN EVERY 5 MIN

METER OPERATED AT   4.0 M FROM BOTTOM IN   4.6 M OF WATFR

TABLE 1.10

LOCATION CODE : 1160   PERIOD   : JUN 74
AREA   : HAMILTON HARBOUR   LATITUDE : 43 17 21 N
LAKE   :   ONTARIO   LONGITUDE : 79 47 44 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50- 22.49	22.50- 67.49	67.50- 112.49	112.50- 157.49	157.50- 202.49	202.50- 247.49	247.50- 292.49	292.50- 337.49	ROW SUMS
1.00 -- 1.99	3.42	2.09	3.13	5.83	3.78	2.19	2.43	2.82	25.70
2.00 -- 2.99	1.92	0.88	1.82	8.59	7.86	0.98	0.53	1.23	23.81
3.00 -- 3.99	0.57	0.25	0.70	5.38	6.83	0.23	0.06	0.41	14.42
4.00 -- 4.99	0.06	0.06	0.55	3.66	5.26	0.08	0.04	0.43	10.15
5.00 -- 5.99	0.06	0.0	0.06	3.50	5.69	0.10	0.04	0.02	9.47
6.00 -- 6.99	0.0	0.0	0.0	2.27	3.54	0.04	0.06	0.0	5.91
7.00 -- 12.99	0.0	0.0	0.0	3.17	7.12	0.18	0.06	0.0	10.54
COLUMN SUMS	6.04	3.27	6.26	32.41	40.08	3.81	3.23	4.91	100.00

RESULTANT CURRENT IS   2.89 CM/S AT 159 DEG FROM NORTH   TOTAL NO. READINGS   4888

MEAN CURRENT IS   3.77 CM/S   PERSISTENCE IS   0.77

MAXIMUM CURRENT IS   12.67 CM/S   READINGS TAKEN EVERY 5 MIN

METER OPERATED AT   14.6 M FROM BOTTOM IN 18.3 M OF WATER

TABLE 1.11

LOCATION CODE : 1160   PERIOD   : JUL 74
AREA   : HAMILTON HARBCUR   LATITUDE : 43 17 21 N
LAKE   : ONTARIO   LONGITUDE : 79 47 44 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50- 22.49	22.50- 67.49	67.50- 112.49	112.50- 157.49	157.50- 202.49	202.50- 247.49	247.50- 292.49	292.50- 337.49	ROW SUMS
0.0 -- 0.30	0.0	0.0	0.0	0.0	0.45	0.0	0.0	0.0	0.45
0.31 -- 0.99	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.02
1.00 -- 1.99	2.59	2.16	2.90	3.12	2.95	1.82	1.60	2.00	19.15
2.00 -- 2.99	3.39	2.51	3.99	7.03	8.98	2.13	1.12	2.85	32.00
3.00 -- 3.99	1.57	0.53	1.25	4.91	6.42	0.61	0.22	1.82	17.34
4.00 -- 4.99	1.09	0.10	0.16	3.52	5.87	0.42	0.06	1.63	12.85
5.00 -- 13.99	0.80	0.05	0.10	4.71	10.18	0.50	0.30	1.57	18.20

| COLUMN SUMS | 9.44 | 5.35 | 8.39 | 23.31 | 34.85 | 5.47 | 3.31 | 9.88 | 100.00 |

RESULTANT CURRENT IS   1.77 CM/S AT   161 DEG FROM NORTH   TOTAL NO. READINGS   6247

MEAN CURRENT IS   3.57 CM/S   PERSISTENCE IS   0.50

MAXIMUM CURRENT IS   13.20 CM/S   READINGS TAKEN EVERY   5 MIN

                    METER OPERATED AT   14.6 M FROM BOTTOM IN   18.3 M   OF WATER

TABLE 1.12

LOCATION CODE : 1180
AREA   : HAMILTON HARBOUR
LAKE   :   ONTARIO

PERIOD   : JUN 74
LATITUDE : 43 16 31 N
LONGITUDE : 79 47 24 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50– 22.49	22.50– 67.49	67.50– 112.49	112.50– 157.49	157.50– 202.49	202.50– 247.49	247.50– 292.49	292.50– 337.49	ROW SUMS
0.0 -- 0.30	0.95	2.39	7.60	12.72	19.57	7.07	5.90	3.82	60.03
0.31 -- 0.99	0.43	0.30	0.56	2.60	5.95	0.30	1.30	1.17	12.63
1.00 -- 1.99	0.39	0.0	0.35	2.30	4.25	0.04	0.107	0.65	8.16
2.00 -- 2.99	0.0	0.04	0.17	1.00	3.30	0.09	0.04	0.43	5.08
3.00 -- 3.99	0.0	0.0	0.04	0.95	2.73	0.0	0.0	0.04	3.78
4.00 -- 4.99	0.0	0.0	0.04	1.30	2.65	0.0	0.0	0.09	4.08
5.00 -- 8.99	0.0	0.0	0.0	0.52	5.60	0.0	0.0	0.13	6.25
COLUMN SUMS	1.78	2.73	8.77	21.40	44.05	7.51	7.42	6.34	100.00

RESULTANT CURRENT IS   0.97 CM/S AT 166 DEG FROM NORTH   TOTAL NO. READINGS   2304

MEAN CURRENT IS   1.04 CM/S   PERSISTENCE IS   0.93

MAXIMUM CURRENT IS   8.80 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   5.5 M FROM BOTTOM IN 10.7 M OF WATER

TABLE 1.13

LOCATION CODE : 1180
AREA   : HAMILTON HARBOUR
LAKE   :   ONTARIO

PERIOD   :   JUL 74
LATITUDE : 43 16 31 N
LONGITUDE : 79 47 24 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	2.16	6.87	7.68	7.87	14.13	3.90	2.03	3.00	47.66
0.31 -- 0.99	0.97	0.52	0.65	1.81	7.00	0.42	0.48	1.13	12.97
1.00 -- 1.99	1.16	0.32	0.35	2.26	7.52	0.06	0.06	0.97	12.71
2.00 -- 2.99	0.97	0.10	0.10	1.29	5.36	0.13	0.06	0.45	8.45
3.00 -- 3.99	0.45	0.0	0.0	0.71	5.03	0.0	0.0	0.58	6.78
4.00 -- 4.99	0.19	0.0	0.0	0.39	3.65	0.0	0.0	0.16	4.39
5.00 -- 10.99	0.23	0.0	0.0	0.26	6.55	0.0	0.0	0.0	7.03
COLUMN SUMS	6.13	7.81	8.78	14.59	49.24	4.52	2.65	6.29	100.00

RESULTANT CURRENT IS   1.09 CM/S AT   169 DEG FROM NORTH   TOTAL NO. READINGS   3099

MEAN CURRENT IS   1.39 CM/S   PERSISTENCE IS   0.79

MAXIMUM CURRENT IS   10.55 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   5.5 M FROM BOTTOM IN 10.7 M OF WATER

TABLE 1.14

LOCATION CODE : 1110   PERIOD   : SEP 72
AREA   : BURLINGTON CANAL   LATITUDE : 43 17 53 N
LAKE   : ONTARIO   LONGITUDE : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50–22.49	22.50–67.49	67.50–112.49	112.50–157.49	157.50–202.49	202.50–247.49	247.50–292.49	292.50–337.49	ROW SUMS
0.0 -- 0.30	0.05	0.0	0.0	0.0	0.0	0.05	0.0	0.05	0.16
0.31 -- 2.99	1.57	2.82	3.31	0.43	0.54	2.01	3.47	0.60	14.75
3.00 -- 5.99	2.44	3.04	7.05	0.11	0.05	2.66	6.40	0.81	22.56
6.00 -- 8.99	2.66	2.28	6.07	0.0	0.16	1.74	5.53	0.54	18.98
9.00 -- 11.99	2.49	1.84	5.26	0.05	0.05	1.03	4.28	0.16	15.18
12.00 -- 14.99	1.84	1.52	3.63	0.0	0.0	0.65	3.85	0.0	11.50
15.00 -- 45.99	2.77	2.66	4.18	0.0	0.0	0.76	6.45	0.05	16.87
COLUMN SUMS	13.83	14.15	29.50	0.60	0.81	8.89	29.99	2.22	100.00

RESULTANT CURRENT IS   2.03 CM/S AT   0 DEG FROM NORTH   TOTAL NO. READINGS   1844

MEAN CURRENT IS   9.38 CM/S   PERSISTENCE IS   0.22

MAXIMUM CURRENT IS   45.08 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   2.1 M FROM BOTTOM IN 9.4 M OF WATER

TABLE 1.15

LOCATION CODE : 1110   PERIOD   : OCT 72
AREA   : BURLINGTON CANAL   LATITUDE   : 43 17 53 N
LAKE   : ONTARIO   LONGITUDE   : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	0.02	0.16	0.32	0.04	0.02	0.0	0.18	0.04	0.77
0.31 -- 6.99	0.93	7.02	12.78	0.79	0.77	5.29	12.39	0.81	40.79
7.00 -- 13.99	0.50	3.47	12.73	0.10	0.04	4.32	12.63	0.28	34.05
14.00 -- 20.99	0.30	0.79	4.82	0.02	0.0	1.92	6.44	0.04	14.33
21.00 -- 27.99	0.10	0.24	1.76	0.0	0.0	1.03	2.78	0.0	5.91
28.00 -- 34.99	0.04	0.06	0.54	0.0	0.0	0.30	0.95	0.0	1.88
35.00 -- 122.99	0.0	0.16	0.48	0.0	0.0	0.16	1.47	0.0	2.26
COLUMN SUMS	1.88	11.89	33.42	0.95	0.83	13.02	36.83	1.17	100.00

RESULTANT CURRENT IS   1.74 CM/S AT   262 DEG FROM NORTH   TOTAL NO. READINGS   5045

MEAN CURRENT IS   10.59 CM/S   PERSISTENCE IS   0.16

MAXIMUM CURRENT IS   122.72 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   2.1 M FROM BOTTOM IN   9.4 M OF WATER

TABLE 1.16

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	0.0	0.0	0.58	0.0	0.39	0.0	0.10	0.0	1.07
0.31 -- 2.99	0.0	0.0	0.58	0.0	0.29	0.39	1.74	0.39	3.39
3.00 -- 5.99	0.39	0.78	2.23	0.78	0.87	2.03	4.65	0.39	12.11
6.00 -- 8.99	0.39	0.97	3.59	0.10	0.87	1.36	7.17	0.39	14.83
9.00 -- 11.99	0.39	1.07	5.72	0.10	0.78	0.97	7.95	0.78	17.73
12.00 -- 14.99	0.29	0.48	4.65	0.19	0.19	0.78	6.10	0.29	12.98
15.00 -- 42.99	1.16	1.65	16.38	0.48	0.39	0.87	16.18	0.78	37.89
COLUMN SUMS	2.62	4.94	33.72	1.65	3.78	6.40	43.90	3.00	100.00

RESULTANT CURRENT IS   1.10 CM/S AT 312 DEG FROM NORTH   TOTAL NO. READINGS   1032

MEAN CURRENT IS   13.87 CM/S   PERSISTENCE IS   0.08

MAXIMUM CURRENT IS   42.59 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   2.1 M FROM BOTTOM IN   9.4 M OF WATER

TABLE 1.17

LOCATION CODE : 1110
AREA : BURLINGTON CANAL
LAKE : ONTARIO

PERIOD : MAY 73
LATITUDE : 43 17 53 N
LONGITUDE : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50- 22.49	22.50- 67.49	67.50- 112.49	112.50- 157.49	157.50- 202.49	202.50- 247.49	247.50- 292.49	292.50- 337.49	ROW SUMS
0.0 -- 0.30	0.0	0.27	0.07	0.02	0.0	0.0	0.15	0.05	0.57
0.31 -- 7.99	0.40	1.79	0.27	0.07	0.02	0.05	2.09	0.35	5.04
8.00 -- 15.99	0.50	3.08	0.55	0.07	0.15	0.17	2.93	0.74	8.19
16.00 -- 23.99	0.35	3.05	0.60	0.07	0.0	0.10	2.91	0.87	7.95
24.00 -- 31.99	0.27	2.71	0.52	0.07	0.10	0.30	3.82	0.79	8.59
32.00 -- 39.99	0.20	2.88	0.35	0.0	0.02	0.22	3.80	0.37	7.85
40.00 -- 142.99	1.74	25.23	2.78	0.20	0.62	0.94	27.19	3.10	61.81
COLUMN SUMS	3.45	39.01	5.14	0.52	0.92	1.79	42.89	6.28	100.00

RESULTANT CURRENT IS   15.06 CM/S AT 340 DEG FROM NORTH   TOTAL NO. READINGS   4027

MEAN CURRENT IS   55.21 CM/S   PERSISTENCE IS   0.27

MAXIMUM CURRENT IS   142.52 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN   9.4 M OF WATER

TABLE 1.18

LOCATION CODE : 1110
AREA   : BURLINGTON CANAL
LAKE   :   ONTARIO

PERIOD   :   JUN 73
LATITUDE : 43 17 53 N
LONGITUDE : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	0.03	0.08	0.03	0.0	0.0	0.0	0.0	0.03	0.15
0.31 -- 7.99	0.31	1.77	0.49	0.28	0.23	0.21	0.69	0.33	4.32
8.00 -- 15.99	0.18	2.29	0.69	0.05	0.13	0.26	1.57	0.49	5.66
16.00 -- 23.99	0.39	3.16	0.98	0.13	0.15	0.51	2.03	0.44	7.79
24.00 -- 31.99	0.54	4.01	1.00	0.08	0.26	0.23	2.57	0.28	8.98
32.00 -- 39.99	0.64	4.60	0.95	0.05	0.18	0.26	2.52	0.28	9.49
40.00 -- 143.99	3.94	33.36	4.24	0.72	1.54	1.77	15.69	2.34	63.61
COLUMN SUMS	6.02	49.28	8.38	1.31	2.49	3.24	25.08	4.19	100.00

RESULTANT CURRENT IS   21.73 CM/S AT   39 DEG FROM NORTH   TOTAL NO. READINGS   3888

MEAN CURRENT IS   56.19 CM/S   PERSISTENCE IS   0.39

MAXIMUM CURRENT IS   143.77 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN   9.4 M OF WATER

TABLE 1.19

LOCATION CODE : 1110
AREA   : BURLINGTON CANAL
LAKE   : ONTARIO

PERIOD   : JUL 73
LATITUDE : 43 17 53 N
LONGITUDE : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50- 22.49	22.50- 67.49	67.50- 112.49	112.50- 157.49	157.50- 202.49	202.50- 247.49	247.50- 292.49	292.50- 337.49	ROW SUMS
0.0 -- 0.30	0.04	0.02	0.02	0.0	0.0	0.22	0.13	0.07	0.52
0.31 -- 3.99	0.72	2.28	9.16	0.94	0.72	5.09	4.50	0.85	24.26
4.00 -- 7.99	0.38	1.99	14.81	0.52	0.56	3.52	4.68	0.69	27.15
8.00 -- 11.99	0.16	0.92	15.21	0.07	0.16	1.66	2.80	0.13	21.10
12.00 -- 15.99	0.07	0.56	11.38	0.0	0.04	0.69	1.01	0.07	13.82
16.00 -- 19.99	0.0	0.11	6.85	0.0	0.0	0.11	0.58	0.02	7.68
20.00 -- 60.99	0.0	0.20	4.53	0.0	0.0	0.09	0.65	0.0	5.47
COLUMN SUMS	1.37	6.09	61.96	1.52	1.48	11.38	14.36	1.84	100.00

RESULTANT CURRENT IS   5.13 CM/S AT   80 DEG FROM NORTH   TOTAL NO. READINGS   4464

MEAN CURRENT IS   8.85 CM/S   PERSISTENCE IS   0.58

MAXIMUM CURRENT IS   60.08 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN   9.4   M   OF WATER

TABLE 1.20

LOCATION CODE : 1110
AREA   : BURLINGTON CANAL
LAKE   : ONTARIO

PERIOD   : AUG 73
LATITUDE   : 43 17 53 N
LONGITUDE : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	0.06	0.03	0.19	0.13	0.0	0.06	0.35	0.0	0.82
0.31 -- 1.99	0.47	1.20	3.57	0.28	0.54	2.05	2.21	0.60	10.93
2.00 -- 3.99	0.73	1.67	7.77	0.57	0.51	2.53	3.50	0.51	17.78
4.00 -- 5.99	0.41	1.36	8.97	0.38	0.35	1.93	2.97	0.47	16.83
6.00 -- 7.99	0.22	0.95	8.84	0.19	0.16	0.88	2.34	0.19	13.77
8.00 -- 9.99	0.03	0.60	7.04	0.16	0.0	0.41	1.74	0.09	10.07
10.00 -- 31.99	0.06	1.29	25.96	0.13	0.03	0.47	1.80	0.06	29.81
COLUMN SUMS	1.99	7.10	62.33	1.83	1.58	8.34	14.90	1.93	100.00

RESULTANT CURRENT IS   4.89 CM/S AT   77 DEG FROM NORTH   TOTAL NO. READINGS   3167

MEAN CURRENT IS   7.63 CM/S   PERSISTENCE IS   0.64

MAXIMUM CURRENT IS   31.54 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN   9.4 M OF WATER

TABLE 1.21

LOCATION CODE : 1110   PERIOD   : JUN74
AREA   : BURLINGTON CANAL   LATITUDE : 43 17 53 N
LAKE   : ONTARIO   LONGITUDE : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	0.0	0.69	0.94	0.0	0.16	0.61	0.45	0.0	2.86
0.31 -- 2.99	0.12	4.37	6.82	0.33	0.16	2.78	5.47	0.16	20.22
3.00 -- 5.99	0.41	3.92	10.87	0.94	0.12	2.17	5.68	0.16	24.26
6.00 -- 8.99	0.08	2.41	9.40	0.49	0.04	1.72	4.13	0.0	18.26
9.00 -- 11.99	0.04	0.78	5.80	0.20	0.04	1.23	3.43	0.0	11.52
12.00 -- 14.99	0.0	0.25	5.23	0.12	0.04	0.53	2.17	0.0	8.33
15.00 -- 42.99	0.0	0.61	6.99	0.12	0.04	1.31	5.47	0.0	14.54
COLUMN SUMS	0.65	13.03	46.04	2.21	0.61	10.33	26.80	0.33	100.00

RESULTANT CURRENT IS   1.48 CM/S AT   82 DEG FROM NORTH   TOTAL NO. READINGS   2448

MEAN CURRENT IS   8.13 CM/S   PERSISTENCE IS   0.18

MAXIMUM CURRENT IS   42.90 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN 9.4 M OF WATER

TABLE 1.22

LOCATION CODE : 1110
AREA   : BURLINGTON CANAL
LAKE   :   ONTARIO

PERIOD   : JUL74
LATITUDE : 43 17 53 N
LONGITUDE : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50- 22.49	22.50- 67.49	67.50- 112.49	112.50- 157.49	157.50- 202.49	202.50- 247.49	247.50- 292.49	292.50- 337.49	ROW SUMS
0.0 -- 0.30	0.03	0.58	0.64	0.0	0.0	0.23	0.42	0.16	2.06
0.31 -- 2.99	0.26	2.61	5.93	0.23	0.16	1.61	2.42	0.29	13.51
3.00 -- 5.99	0.03	2.80	9.19	0.26	0.16	2.19	2.87	0.13	17.63
6.00 -- 8.99	0.0	2.45	9.64	0.0	0.06	1.23	2.06	0.03	15.47
9.00 -- 11.99	0.16	1.71	11.03	0.0	0.0	0.74	1.16	0.06	14.86
12.00 -- 14.99	0.06	0.90	10.96	0.0	0.0	0.52	0.84	0.03	13.31
15.00 -- 40.99	0.0	1.29	18.25	0.0	0.0	1.32	2.26	0.03	23.15
COLUMN SUMS	0.55	12.35	65.64	0.48	0.39	7.83	12.02	0.74	100.00

RESULTANT CURRENT IS   6.70 CM/S AT   74 DEG FROM NORTH   TOTAL NO. READINGS   3102

MEAN CURRENT IS   10.28 CM/S   PERSISTENCE IS   0.65

MAXIMUM CURRENT IS   40.61 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN   9.4 M OF WATER

TABLE 1.23

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	0.54	1.51	0.43	0.15	0.97	0.62	0.35	0.89	5.45
0.31 -- 2.99	0.97	4.52	3.98	1.35	1.85	4.25	4.95	1.62	23.49
3.00 -- 5.99	0.46	5.60	4.68	1.04	0.73	4.02	4.91	0.54	21.99
6.00 -- 8.99	0.19	5.37	3.63	0.31	0.23	3.28	2.90	0.23	16.15
9.00 -- 11.99	0.04	3.86	1.39	0.04	0.0	1.47	2.70	0.08	9.58
12.00 -- 14.99	0.0	2.90	1.08	0.0	0.0	0.77	1.78	0.0	6.53
15.00 -- 44.99	0.08	7.84	1.58	0.08	0.0	1.16	6.07	0.0	16.81
COLUMN SUMS	2.28	31.61	16.77	2.98	3.79	15.57	23.65	3.36	100.00

RESULTANT CURRENT IS   1.02 CM/S AT   41 DEG FROM NORTH   TOTAL NO. READINGS   2588

MEAN CURRENT IS   8.31 CM/S   PERSISTENCE IS   0.12

MAXIMUM CURRENT IS   44.51 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN   9.4 M OF WATER

TABLE 1.24

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50- 22.49	22.50- 67.49	67.50- 112.49	112.50- 157.49	157.50- 202.49	202.50- 247.49	247.50- 292.49	292.50- 337.49	ROW SUMS
0.0 -- 0.30	1.02	6.36	0.97	2.00	2.30	3.13	2.74	0.97	19.49
0.31 -- 2.99	0.97	5.08	1.83	1.53	1.53	2.72	3.62	0.81	18.10
3.00 -- 5.99	0.44	4.06	2.07	1.04	0.63	3.90	2.62	0.49	15.25
6.00 -- 8.99	0.30	3.83	1.44	0.37	0.21	3.13	2.67	0.12	12.07
9.00 -- 11.99	0.02	2.83	1.28	0.09	0.07	1.81	2.76	0.14	9.00
12.00 -- 14.99	0.02	2.37	0.60	0.07	0.02	1.55	2.58	0.0	7.22
15.00 -- 44.99	0.0	4.71	1.49	0.05	0.05	4.57	8.01	0.0	18.87
COLUMN SUMS	2.78	29.24	9.68	5.15	4.80	20.82	24.99	2.53	100.00

RESULTANT CURRENT IS   1.76 CM/S AT 255 DEG FROM NORTH   TOTAL NO. READINGS   4309

MEAN CURRENT IS   7.94 CM/S   PERSISTENCE IS   0.22

MAXIMUM CURRENT IS   44.23 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   6.1 M FROM BOTTOM IN   9.4 M OF WATER

TABLE 1.25

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50- 22.49	22.50- 67.49	67.50- 112.49	112.50- 157.49	157.50- 202.49	202.50- 247.49	247.50- 292.49	292.50- 337.49	ROW SUMS
0.0 -- 0.30	0.04	0.0	0.0	0.12	0.27	0.15	0.58	0.35	1.51
0.31 -- 2.99	0.50	0.15	2.24	1.31	0.69	1.70	2.55	1.04	10.19
3.00 -- 5.99	1.00	0.93	4.09	0.77	0.62	1.43	6.95	1.00	16.79
6.00 -- 8.99	0.42	0.27	4.21	0.27	0.19	0.89	9.57	0.50	16.33
9.00 -- 11.99	0.04	0.19	3.78	0.0	0.04	0.39	9.84	0.42	14.70
12.00 -- 14.99	0.04	0.12	2.35	0.04	0.04	0.19	8.22	0.08	11.08
15.00 -- 46.99	0.0	0.15	5.67	0.0	0.08	0.15	23.35	0.0	29.41
COLUMN SUMS	2.05	1.81	22.35	2.51	1.93	4.90	61.06	3.40	100.00

RESULTANT CURRENT IS   6.17 CM/S AT 260 DEG FROM NORTH   TOTAL NO. READINGS   2591

MEAN CURRENT IS   11.78 CM/S   PERSISTENCE IS   0.52

MAXIMUM CURRENT IS   46.50 CM/S   READINGS TAKEN EVERY 10 MIN

                    METER OPERATED AT   7.5 M FROM BOTTOM IN   9.4 M OF WATER

TABLE 1.26

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	0.33	0.38	4.92	0.38	0.61	0.98	12.51	0.20	20.30
0.31 -- 2.99	0.43	0.71	5.02	0.38	1.16	1.13	5.88	0.43	15.13
3.00 -- 5.99	0.81	0.58	4.69	0.13	0.61	1.19	5.80	0.40	14.20
6.00 -- 8.99	0.25	0.25	4.89	0.18	0.25	0.78	6.20	0.23	13.04
9.00 -- 11.99	0.0	0.05	3.13	0.23	0.30	0.25	5.30	0.10	9.36
12.00 -- 14.99	0.08	0.13	2.47	0.03	0.10	0.43	4.92	0.03	8.17
15.00 -- 44.99	0.0	0.13	4.36	0.03	0.08	0.20	15.01	0.0	19.80
COLUMN SUMS	1.89	2.22	29.48	1.34	3.10	4.97	55.61	1.39	100.00

RESULTANT CURRENT IS   3.27 CM/S AT   252 DEG FROM NORTH   TOTAL NO. READINGS   3965

MEAN CURRENT IS   8.23 CM/S   PERSISTENCE IS   0.40

MAXIMUM CURRENT IS   44.94 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   7.5 M FROM BOTTOM IN   9.4   M   OF WATER

TABLE 1.27

LOCATION CODE : 1120   PERIOD   : JUN 74
AREA   : BURLINGTON CANAL   LATITUDE : 43 17 53 N
LAKE   : ONTARIO   LONGITUDE : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	0.0	0.74	3.80	0.0	0.20	0.12	0.08	0.08	5.02
0.31 -- 2.99	0.45	3.68	12.62	0.20	0.29	0.78	0.37	0.12	18.50
3.00 -- 5.99	0.53	4.49	14.91	0.08	0.12	1.55	0.49	0.08	22.26
6.00 -- 8.99	0.37	5.47	12.62	0.16	0.04	0.78	0.12	0.0	19.57
9.00 -- 11.99	0.04	4.53	8.46	0.0	0.0	0.74	0.16	0.0	13.93
12.00 -- 14.99	0.0	3.31	5.43	0.0	0.0	0.16	0.04	0.0	8.95
15.00 -- 39.99	0.0	5.68	5.35	0.0	0.0	0.53	0.20	0.0	11.76
COLUMN SUMS	1.39	27.90	63.19	0.45	0.65	4.66	1.47	0.29	100.00

RESULTANT CURRENT IS   6.66 CM/S AT   66 DEG FROM NORTH   TOTAL NO. READINGS   2448

MEAN CURRENT IS   7.80 CM/S   PERSISTENCE IS   0.85

MAXIMUM CURRENT IS   39.75 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   2.1 M FROM BOTTOM IN   9.4 M   OF WATER

TABLE 1.28

LOCATION CODE : 1120
AREA : BURLINGTON CANAL
LAKE : ONTARIO

PERIOD : JUL 74
LATITUDE : 43 17 53 N
LONGITUDE : 79 47 55 W

FREQUENCY TABLE

DIRECTION (COMING FROM) IN DEGREES

SPEED(CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
0.0 -- 0.30	0.0	1.29	0.0	0.0	0.10	0.26	0.26	0.0	1.90
0.31 -- 2.99	0.39	5.25	0.13	0.06	0.26	1.22	0.39	0.10	7.80
3.00 -- 5.99	0.64	8.25	0.13	0.0	0.23	2.38	0.23	0.16	12.02
6.00 -- 8.99	0.29	10.96	0.0	0.03	0.03	1.26	0.10	0.0	12.67
9.00 -- 11.99	0.10	13.63	0.03	0.03	0.13	1.06	0.06	0.0	15.05
12.00 -- 14.99	0.06	14.76	0.0	0.0	0.0	0.35	0.0	0.0	15.18
15.00 -- 41.99	0.03	33.74	0.03	0.0	0.06	1.51	0.0	0.0	35.39
COLUMN SUMS	1.51	87.88	0.32	0.13	0.81	8.06	1.03	0.26	100.00

RESULTANT CURRENT IS   10.85 CM/S AT   33 DEG FROM NORTH   TOTAL NO. READINGS   3103

MEAN CURRENT IS   12.54 CM/S   PERSISTENCE IS   0.87

MAXIMUM CURRENT IS   41.25 CM/S   READINGS TAKEN EVERY 10 MIN

METER OPERATED AT   2.1 M FROM BOTTOM IN   9.4 M OF WATER